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ABSTRACT

A number of problems exist in society which require the cooperation of physical and social scientists. One of these problems is the current crisis in science education. There are several aspects to this problem, including the declining interest of students in math and science at a time when functioning in our society requires more, not less, working knowledge of basic math and science. Another aspect is the declining attractiveness of teaching careers in math and science, leading to a severe teacher shortage in these areas and inadequate competency of some of the teachers now available. Several factors might explain the shortage, including declining esteem for public school teachers, relatively low salaries, and increased opportunities for women who leave the teaching field for careers in business and industry. Psychologists can play an influential role in establishing, in quantitative terms, the reasons for these changes, and can focus on developing methodologies for stimulating student interest in math, science, and computer literacy. More technological changes can be expected, and opportunities will increase for psychologists and social scientists to help people adjust to them. The increasing national need for physical scientists and engineers has implications for women in these fields. Psychologists should be encouraged to study social impediments inhibiting women from considering physical science careers, and to develop ways of motivating women students to take the necessary courses. The need for support mechanisms for women and minority students in these fields is increasing. The time has come for increased interaction between physical and behavioral scientists. (JAC)

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CURRENT CRISIS IN SCIENCE EDUCATION? WOMEN IN SCIENCE AND PROBLEMS FOR THE BEHAVIORAL SCIENTIST.

SOME PERSPECTIVES OF A PHYSICIST

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LECTURE

MILDRED S. DRESSELHAUS

As I see the psychology profession from the outside, it appears that most of your concerns deal with the most vital matters of the life cycle, and interpersonal relations relevant to these vital matters; It is obvious that I cannot in any way contribute to your thinking on the most vital issues of life and death;birth, childhood, adolescence, marriage, child rearing, retirement, old age. All I can do here is express my sincere appreciation to people like you who are giving their professional lives to the service of mankind, firstly to try to understand these issues and secondly to develop methodologies to motivate people to deal effectively with problems in the life cycle.

The set of topics which I wish to address are not vital in the sense of life and death, but rather may affect such lesser issues as amenities in our life styles, our international competitiveness and our standard of living. It is clear that the physical and social sciences mesh in many important ways, and it is to this intersection and confluence that I will address my remarks.

The main focus of my talk will be outlining a number of issues facing physical scientists, and also the Nation in some cases, where help from the social scientists is needed to achieve progress; Thus, I hope to outline for you a number of problem areas which cannot be solved unless we work together to solve them.

One of these areas relates to what is called The Current Crisis in Science Education, the first topic I will address. The current crisis is really not so current, but has been with us for a decade or more. What is current is the new national attention being given to this problem and the optimism that is present in some quarters that things will begin to improve, rather that continue to deteriorate; So what are the issues?

The crisis in science education has several aspects. In a nutshell, the crisis concerns the declining interest of students in math and science at a time when functioning in our society at almost any level requires a greater (not lesser) working knowledge of basic math and science. It concerns the declining attractiveness of teaching careers in math and science, leading to a severe teacher shortage in these areas and inadequate competency of many of the teachers who are now teaching math and science to our children. Let me elaborate on these issues in slightly more detail.

With regard to the students, the facts are that there has been a decline in student interest in the sciences over the past decade; As a physical scientist, I am frankly at a loss to explain the reason for this declining interest at a visceral level, though I will give reasons why the phenomenon seems to have occurred. To me, math and science have great inherent interest. For a child, science explains why and how things work in the world in which we live. For the adolescent, the explanation of many of these same phenomenon can be revisited at a more sophisticated and quantitative level. After all, we

at a more sophisticated and quantitative level. After all, we live in a world where science and technology are all pervasive. We are entering an era which has been called the Information Age, where the use of the Computer will enormously affect how we conduct our business. Weighty issues which affect our lives lie at the crossroads between science, technology and public policy, such as energy resources for our future, how to control our environment, how to cope with accelerating technological change. How can a citizen make intelligent choices on these issues without some elementary understanding of the technical issues?

The reasons why students need to study more math and science in primany schools, secondary schools and colleges has been widely documented by scholarly works of individuals and by national studies. Let me make two additional comments relevant to these concerns. Firstly, let me say that I have commonly heard professionals not in the physical sciences and engineering express regrets for not having had a better math and science background when faced with the rapid technological changes taking place in their fields today. Furthermore, for us to remain industrially competitive with Western Europe and Japan, it will be increasingly important for our workforce to have an equivalent level of competence in comparison with workers in these nations. Unless something is done to bring the education level of our workers on a par with that of our competitors, it may become increasingly difficult for us to compete while providing present levels of compensation and standard of living to our workers.

As I see it, there are three basic reasons for the perceived decline in student interest in math and science. Firstly, math and science courses are often more challenging for students, requiring more concentration and commitment than other courses. Thus, many students prefer to take the easy way out, and to take only the minimum requirements in these areas. It is believed that the fear of poor grades inhibits many students from studying more math and science. Secondly the declining quality of math and science instruction in our schools results in a presentation of material that is not as captivating as it could or should be. As a mother and

citizen in the community, I am aware that the quality of the math and science instruction falls far short, on the average, when compared, for example, with the quality of English instruction. Perhaps the social scientists also have similar feelings with regard to the quality primary and secondary education in their fields - I cannot really speak for them. Thirdly, I feel that we often leave students with too many options for free choice; If we, as responsible adults, feel strongly that there are certain basic skills which every citizen should have, then the required curricula should provide for mechanisms to equip young people with these skills; I am a great believer in free choice and individuality, but the free choice should be available only after the basics have been mastered. Raising the math and science requirements for high school graduation or college entrance would also address the fear of low grades syndrome.

Let us now look at the education crisis from the point of view of the teachers. Interest in careers in the teaching profession has declined in general; This is largely due to the demographic changes associated with the decreasing birth rate that started a decade ago. These demographic changes have resulted in fewer teaching jobs in primary schools at first, and later in secondary schools. At the same time there was a perceived retrenchment in public investment in education programs, as expressed by such legislation as Proposition 1' in California and Proposition 21/2 in my own state of Massachusetts. While the general need for teachers has declined, an increasing and unfilled demand for teachers has developed in specific areas, such as math, science, computers and perhaps others with which I have less familiarity.

The gap between supply and demand for teachers in these critical areas has been increasing over the past decade for at least 3 reasons. Firstly, the perception of declining opportunity in the teaching profession has discouraged students from entering teaching in

general, but especially these specialized areas of the teaching profession. Furthermore, the numerous and lucrative professional opportunities in industry for people with skills in the math, science and computer areas have diverted students with such talents away from teaching; The third reason is closely linked with the women's movement. In former years, many of the teaching jobs were filled by women; this was at a time when there were few professional opportunities available to women. But times have changed. Women, who years ago were teaching math and science in junior high schools and high schools are now teaching at universities or employed in challenging and well paid industrial research and development positions.

Teaching at the primary and secondary levels has never been well paid in comparison with most other professions. This may be due to either of the following reasons or perhaps both. For many years, teaching in the public schools was dominated by women; and women workers have traditionally received lower wages for their work in comparison with men. Secondly, our public school systems have traditionally been funded by local property taxes, and people simply don't like to see their property taxes rise; and certainly, there are grave objections to increases in property taxes that exceed the consumer price index or the inflation rate. Thus it has been difficult, and will continue to be difficult, to raise teachers salaries significantly under present funding constraints, unless each teacher does more work and fewer teachers are needed to teach our youth. Increasing the productivity of teachers has been discussed seriously in private universities in this context, but I am not aware of any similar discussions for public school teachers. Though an interesting idea, it is probably not a practical one. Perhaps psychologists can offer some insight into the feasibility of such a proposition. If increasing teacher productivity significantly is not practical, we must then face up to finding a different mechanism for funding public education. Perhaps, greater contributions to the funding of public education should come through income tax at the state level.

I spoke above about the <u>quantity</u> of teachers. Let me now

offer some comments about the quality of teachers. Many of us perceive that on the average, young people choosing teaching careers today are less intelligent than was the case a generation age, and I believe that quantitative studies by a spectrum of social scientists bear this out. There are several factors which might explain these changes in the teaching profession. One major factor is the declining societal esteem for a public school teacher. A second factor is the relatively low compensation rates, discussed above. A third reason is the dominance of women in the field; and as professional opportunities for women opened up in areas of greater societal esteem and higher pay scales, the more talented women tended to leave the teaching profession for other opportunities.

Thus, for a variety of reasons, we, as a nation, are not giving adequate attention and priority to investment in the human resources of the future.I believe that we must give higher priority on our national agenda to the education of our youth. To make this happen, it will be necessary for psychologists and other social scientists to make a quantitative assessment of the present educational situation and of prospects for the future if we continue on our present course. And if there is a need for changes in priorities, we need the guidance of psychologists to point the ways these changes might occur in a manner both acceptable to society, and affordable by society. We then need psychologists to motivate the public to establish national educational goals for the achievement of certain educational standards. This statement clearly implies the need for psychologists and other social scientists to develop reliable, quantitative indicators against which we can measure these educational standards, both on academic and non-academic levels.

These comments were about teaching in general. Now allow me to focus on teaching in the math and science areas. The shortage of qualified math and science teachers, discussed above, has resulted in a decline in the competence level of people who are today teaching in these areas. Let us for a moment focus on

physics because this is my field. From a conceptual point of view, physics is a difficult subject. Physics concepts are difficult for students to understand and also difficult for teachers to convey. Teaching elementary physics at the college level is a very challenging teaching assignment for a professional physicist, including physicist with international reputations in the field. The distressing fact is that the average American high school physics teacher today has no more than one year of college physics training. Since this is the average, then many high school teachers have less than one year of college physics, and in fact some have no formal training in physics at all. Under these circumstances, it is difficult to imagine how high school training in physics can possibly be satisfactory.

Having addressed a few of the grave problems being encountered today in the science education field, let me now identify some areas where psychologists can play an influential role. With regard to the declining interest in math and science, psychologists can be helpful in establishing in more quantitative terms the reasons for declining student interest. Having made this identification, psychologists can then focus on developing methodologies for stimulating student interest and motivating students to develop skills in broad areas of general utility in the life cycle. Because of the growing importance of science and technology in our society, an increased knowledge of math and science concepts will be needed to cope with life itself and to function as informed citizens in the next century.

It is already evident that computer literacy will be a basic skill of the 1980s and 1990s, along with reading, writing and arithmetic; it will be a skill needed by both blue and white collar workers to function in a professional capacity. The teaching of computer literacy will necessitate a rethinking of how math is taught in the schools today. The widespread availability of computers and computer graphics may provide new teaching methods for other subjects that are more effective, engaging, productive and efficient. Much research will be needed by

psychologists and other social scientists to identify areas where computer technology can be effectively utilized, how to train teachers to work with this new technology, and how to provide an appropriate interface between the student, the new technology and the teacher.

We can expect major technological changes to occur in the coming decades, based on what has been happening for the past 50 years and more. The educational system will have to be responsive and resilient to the push and pull of a rapidly advancing technology. What I am trying to say is that the advent of the computer as we know it today is just the tip of the iceberg. Many aspects of the present crisis in education are therefore going to be with us on an on-going basis for a long time to come. We are going to have to learn how to build regenerative elements into our educational enterprise. Psychologists and social scientists are needed to address the problems associated with current shortages of qualified teachers in critical areas such as math and science. Their guidance is also needed in rethinking the training of teachers, so that self-education and continuing education programs in new subject matter, teaching materials and technologies become standard operating procedures for the profession. The opportunities for psychologists and social scientists to make vital contributions toward incorporating technological changes into the educational process are vast and largely unexplored. Without the social scientists, the technologists will have little impact. We need each other to make progress in this important area.

Before leaving the interesting and important topic of the crisis in science education, I would like to comment briefly on the importance of increased math and science education at the college level. I have already repeated something that many others have said before me, that the effect of science and technology on our daily lives is going to increase into the foreseeable future, and probably to increase at an <u>increasing rate</u> (that is, with a positive first and second derivative). To cope with these

changes in a rational way, citizens will need more basic understanding of the technical issues. Also to do our jobs, social scientists and other professionals will need more technical skills. It is already clear that increased computer literacy will be needed for a career in the social sciences. It is evident that more sophisticated use of computer will open up new research opportunities in the social sciences. Many interesting problems in psychology, which have not received much attention in the past will be at interface areas between psychology and other fields, such as the physical sciences. In my talk today, I will focus on a few of these interface areas. However, to conduct research work in these areas, significant knowledge of both fields is necessary. This is in part dictated by the different vocabularies, concepts and approaches of psychology and the physical sciences.

Physicists today are concerned about many issues of physics and public policy. In fact, the American Physical Society has a very active Panel on Public Affairs and a large forum on Physics and Society. In many areas of physics and public policy, the human interface is very important. To be effective in these areas the physicists desperately need your help, wisdom and expertise. We have to start talking more to each other, and to learn how to do this more effectively. This will require learning on both sides, becoming conversant in each other's vocabulary, and establishing some common national goals and priorities in math and science education.

I now come to my second topic, women in science; It was through our mutual interest in women in science that I first met Janet Spence, your President-elect. It was for this reason that the topic of women in science became one of the topics for this talk. I hadn't planned to discuss further why I stumbled into a career in physics. For many of us women who entered the field years ago our entry was quite random and unpalanned. The experience has however been highly rewarding.

Historically, the number of women choosing careers in the physical sciences has been small. For example, let us consider my research fields of solid state physics and electrical engineering. In physics, women comprise about 3% of the professionals, whereas in electrical

engineering, the numbers are even smaller. Although these numbers are small, they are increasing, especially in the engineering fields where women now comprise 20 to 25% of the undergraduate engineering classes, though the numbers are much smaller at the graduate level. Increases in the physical sciences have been much smaller, and significantly fewer than 10% of the current Ph.Ds in physics are women.

Increasing the number of women in the physical sciences and engineering is a matter of current national concern because of demographic changes in this decade. On the one hand, the dramatic growth of hi-tech industries in this decade has been vital to our economic well-being, and has created an expanding need for technically trained personnel; that is people in the physical sciences and engineering. On the other hand, the declining birth rate coupled with a declining emphasis on math and science in our secondary schools portends a dramatic shortage of physical scientists and engineers, unless women and minorities begin to participate in these fields in numbers more closely related to their percentage of the population. Thus, the increasing national need for physical scientists and engineers to maintain our economic growth and competitiveness has serious implications on women in science and engineering. Either we will have to do a better job at training our own citizens or we will have to become increasingly dependent on other nations for providing us with technical manpower.

A second pertinent demographic change relates to the changing participation of women in the American work force. To quote Donna Shalala, president of Hunter College, nearly 60% of all women between 18 and 64 are working outside their homes, thereby accounting for nearly 50 million workers. In view of these numbers, it is not surprising that more than half of all mothers with children under 18 are employed. In fact, the family organization which was the norm in my youth, consisted of a husband, who went to work, while the wife stayed at home to care for the children amd family interest. Only 16% of families today follow this type of family organization. As it appears to me, we have not yet reached a steady state, and every year women are playing an increasing role in the national labor force. As a further

interesting statistic in this context more than half of all college students today are women. Thus I argue that if women are going to be employed anyway, it is important that they work in areas where they have talent, where they derive personal satisfaction and where they are most needed by the nation.

Psychologists are needed to help increase the participation of women and minorities in science and engineering. Firstly, psychologists should be encouraged to continue study of the societal impediments inhibiting women and minorities from considering careers in the physical sciences and engineering. With this information in hand, psychologists are needed to develop effective mechanisms to motivate women and minorities to take the appropriate preparatory courses in high school, and later to enroll as majors in the physical sciences and engineering at college.

Much is already being done by psychologists in this field, with the objective of providing equal opportunities to all, regardless of color or sex. When presented as an altruistic goal, without coupling to the needs of industry to maintain its economic competitiveness, it is difficult to obtain the level of resources necessary to carry out the job. I therefore think it is time for the social scientists to emphasize the economic importance of increasing the numbers of women and minorities in the physical sciences and engineering. Futhermore, by providing additional motivation for women and minorities, it is likely that increased interest in careers in science and engineering will be aroused among all students.

The problems associated with the small numbers of women and minorities in science and engineering go far beyond stimulating greater interest among the youth. Some of the problem areas involve the development of support mechanisms both during the training process and later into their careers. During the last decade we have in fact had considerable experience with both categories of support mechanisms, and significant progress has been made. Nevertheless, much work remains for the social scientists.

I will suggest a few problems that I consider important and interesting. However, before outlining specific problems, I would like to explain my own involvement in this field.

Because of their small numbers, women in science and engineering have formed interdisciplinary support groups. This has occurred both in the university setting and in industry. Through these support groups, strong interdisciplinary interactions have developed between women in the physical sciences, biological sciences, behavioral sciences and engineering. I have been instrumental in establishing such support groups at MIT, and have tried to provide leadership to these activities over the last decade and beyond. Through these efforts, I have had extensive contacts with problems faced by women students and faculty at my own institution. In addition, these efforts have brought me into a close working relation with my colleagues in the social sciences, and fruitful interactions have resulted. I have also been active in this area on the national scene, as has Janet Spence, your president-elect.

The need for support mechanisms for women and minority students in science and engineering arises from both academic and non-academic sources. From the academic side, white women students tend to have nearly the same average formal training in math and science as white males, but generally less hands-on experience with machinery, electronics and computers. Minority students typically have less formal training in math and science and often need to improve their study habits. Obviously, these academic deficiencies must be met in some way.

Our educational system at MIT (and perhaps at other institutions as well) has been geared to deal with students who can overcome their deficiencies without significant external intervention. I have myself seen many students of this type, who not only overcome their academic deficiencies independently, but then go on to surpass many classmates starting with superior academic backgrounds. Some of our women and minority students can do this successfully. I have also seen many other women and

minority students who have the ability to compete successfully with their white male classmates, but nevertheless need academic support services to do so. It is my perception that if appropriate support services are available early in their academic careers (and for some on an almost continuing basis), the students can then engage in a much fuller range of educational options and keep up with their peers. If such support services are not available, two things appear to happen. Firstly, these students tend to avoid the more challenging and competitive majors and seek "softer sciences" where they feel more comfortable. Secondly, if they attempt to enter the more challenging fields or subareas of fields, it seems as if they progressively fall further and further behind their peers.

From an educational standpoint, the professors would like to provide maximum opportunities and challenges to all students. Professors should also be prepared to provide help when needed. But the goal of our educational programs must be to develop people sufficiently motivated, resourceful and aggressive, so that they can continue a lifelong education on their own, after completing their formal schooling. The physical science and engineering fields are fields which develop very rapidly. The same is probably also be true for the social sciences. Therefore, the formal education process must also emphasize the basic tools which will be used throughout a lifetime of self education. What is needed from the psychologists is some guidance on the validity of the perceptions described above. And if valid, we need guidance from the psychologists on how these academic support services should be first provided and subsequently withdrawn as the graduation date approaches.

Women and minority students face even more serious impediments in non-academic areas. I will address most of my remarks to the education of <u>women</u> rather than minority students in the physical sciences and engineering, because of my greater familiarity with the needs of women students.

Some of the most common non-academic impediments for women students focus on their small numbers. Such feelings as

self-counsciousness and timidity about calss participation, concern about making mistakes and appearing foolish, all can attributed at least in part to the small number of women in science and engineering classes.

Self-doubts are often reinforced by even smaller numbers of professional women in these fields encountered by women students. The very small number of professionals gives signals that the probability of success is small. Thus, when many women students experience a "bad day", just as all students must from time to time, these women students tend to become more shaken by the experience, because of seemingly unsupportive external surroundings and prevalent feelings of internal self-doubt; The lack of emotional autonomy in many women students needs to be addressed.

It is my observation that women students performing at the same level of achievement as men students have a lower perception of their achievement than their male cohorts. Women students (and also professionals) often feel insecure about their accomplishments. This insecurity is seen in a number of ways. One manifestation is the woman student who has a straight A record and yet feels inadequate as a student. Another manifestation is the perception held by groups of women students that their average performance is generally below that of their male cohorts, when in fact the records show indistinguishable performance on the basis of multiple indicators. Another example is a pair of lab partners of opposite sexes, where the man does most of the hands-on work and the woman records the data. Yet another example is the general lower aspiration levels of women graduates in comparison to male cohorts of similar accomplishment. Though I feel unqualified to comment on the non-academic impediments faced by minority students, one thing I am certain about is that their impediments are significantly greater than those faced by women.

It is my perception that many of the non-academic impediments faced by women students, and for that matter also women professionals, stems from their small numbers. Another factor of significance is the difference in the upbringing of boys and girls from the cradle through adolescence. Because of the enormous variation in the participation of men and women in a given profession from one

country to another, I do not think there are intrinsic differences between the sexes with regard to ability in the physical sciences and engineering, though such differences cannot be ruled out.

Psychologists are needed to evaluate the relative importance of the various factors in contributing to the non-academic impediments of women students in science and engineering. If the major factor is indeed the small numbers, then the psychologists can help to determine the critical mass of women students, and to increase their aspiration levels. We need psychologists to tell us the extent to which professional women role models are useful in overcoming these impediments, and where supportive male mentors can fulfill an equivalent role. Just as educators are needed to provide students with the technical tools for lifelong self study, psychologists are needed to guide educators in providing students with a proper level of confidence and motivations to carry on such self-study effectively.

In the remaining few minutes I would like to address the last topic of my talk, namely problems for the behavioral scientist, as perceived by a physicist. As I mentioned before, physicists are becoming increasingly concerned about the implications of their science on society and public policy. What is becoming clear is that physicists cannot solve these problems alone, not without the help of social scientists. To have a societal impact, the solution to a problem in science and society, requires social acceptance. Thus physicists have to work together with social scientests to develop approaches that are in fact socially acceptable and environmentally viable. Examples of issues in this category might be energy resources for the future, preservation of our environment, the automation of industrial processes, arms control and national defense.

One of the major problems facing our society today is the rapidity of technological change in society and our limited ability as human beings to adjust to these changes. Technological change and the attendant societal readjustments are not entirely new to us. Social scientists have for many years studied the Industrial Revolution as an example of this phenomenon. There are however some major differences in what happened in the past, and what is happening in the present century. The main difference is related to the shrinking time constant between major technological advances.

Social adjustments to technological change have always been difficult because of the external pressure to change one's way of doing things to remain competitive, and the internal pressure to live under familiar and non-threatening conditions. As long as the time constants for technological change were much longer that a human lifetime, the normal educational processes could to some extent be tailored to retrain people to new ways of doing things, and to equip people to cope with the attendant changes in life style. Such changes occurred historically when the Industrial Revolution shifted the industrial focus from the cottage industries to urban factories, or when a largely agrarian society was transformed into a largely manufacturing and service-oriented society.

However, in the 20th century, the time constant for technological change has become shorter than the average human lifetime. Under this regime, people experience technological obsolescence on the job, and middle aged people have to learn how to cope with being replaced by a younger person versed in the newer technologies, or by an inhuman machine, robot or computer. Concurrent with these technological changes, two societal changes have occurred: the women's movement and the black movemen each partly triggered by technological factors and by societal changes. Psychologists have thus been hard at work at the clinical level, in counselling and in research activities, relating to these societal changes. In fact, as I see the situation in psychology from the outside, the rapid increase in interest in psychology in the past 20 years has in a significant way been stimulated by these societal and technological changes, and the emotional reaction of people to these major and rapid changes.

But the reality of the situation is the short time constant for technological change, which is now approaching a single decade, a time short compared to a professional lifetime and to the period of formal schooling. Because of the close relation between technological change and international industrial competition, I can see no way that the time constant for technological change will remain even at its present short level. Since physical and biological scientists and engineers have some insights into major breakthroughs on the horizon, it will be increasingly important for these researchers to communicate with the behavioral scientists. The psychologists need to understand the technological changesthat are occurring and are about to occur, in order to develop mechanisms to help people, as individuals and as groups cope with a constantly changing and insecure environment. In this connection, let me say that probably the most important factor for change on the horizon is recombinant DNA.

In dealing with technological change, psychologists will be needed for guidance in developing an effective approach to the educational process for children under conditions where the pertinent curriculum relevant to preparation for the life cycle is not clearly defined. The problems of mothers returning to the work force after some time off for raising a family under these rapidly changing conditions will be a topic of interest to psychologists. Their guidance will also be needed to develop mechanisms for lifelong adult education to keep adults professionally viable.

Somewhat related to this issue of human adjustment to technological change is that of human adjustment to harsh and unusual environments. As technology has advanced, previously uninhabitable regions of the earth have been settled, such as the polar regions and highly arid regions. How do people adjust to life under these harsh conditions?

More recently astronauts have ventured into space, and various futurists have conceived of colonies of people on

space stations. I think that it would be interesting for psychologists to consider issues relevant to personal adjustment to life under such unusual environments of physical stress, isolation, and dependence on the proper operation of space equipment, and on the proper operation of the ground control crew and control equipment.

Another real problem involving unusual work environments, that is now emerging, concerns the reactions of humans to working in the dark rooms of robotically operated manufacturing facilities. This should provide an interesting research area for psychologists.

A more important problem on the horizon is the return of a significant portion of workers to the home as a workplace where the workers will use computer terminals to communicate and carry out their work. If this changing work style materializes, new relationships between men, women and children will likely occur and the behavioral scientists may play a significant role in affecting the outcome of the resulting life styles.

Another area where specialized problems can be found in the psychology-physics interface is in developing methodologies that are particularly effective in teaching certain subjects, such as physics. There would be considerable interest in developing and in adopting novel methodologies for teaching physics to make it easier for students to learn, understand and retain.

Study of the analogy between processes in the human brain and in computers has become an active field in the cognitive sciences. Collaborative studies between physicists studying the physics of neural processes and psychologists studying brain processes is already under way. Other interface areas also have potential for significant advances.

Technological advances have made possible new options to our society. For example, the control of nuclear processes has made possible the generation of power by fission and major efforts are now in progress to harness fusion for power generation. With each new technology, there are risks and benefits. And in the end, it is society that must make the decision on whether a

given technology is adopted at all, and under which constraints it might be utilized. In many cases, decisions on such issues have in the past been made on a highly emotional level, without proper assessment of the technical facts. The technical issues are often complex, and the decision is not clear-cut. If the physical, biological and behavioral scientists and engineers would develop a more effective framework to assess the risks and benefits of new technologies on a more thoughtful way by the public. issues could be discussed in a more rational way by the public. We already have a number of issues on science and society demanding such discussions, including arms control and defense, control of the environment, alternating energy sources, to mention a few. It is clear that many additional issues in science and society will surface in the next few years. The physical scientists must learn better how to convey the essence of technological issues to the behavioral scientists. By the same token, the behavioral scientists must learn how to work with the physical scientists to develop a solution to the problem that is societally acceptable, and then to help gain social acceptance for this solution.

In the above, I have enumerated a few problems of potential interest to psychologists. Solutions to some of these problems are very important to people in the physical sciences. Time permitting, I am sure that we could come up with many more topics of overlapping interest. The main point I would like to make in closing is that the time has come for increased interaction between the physical and behavioral scientists. We, in the physical sciences, generate a number of issues that may provide intellectually stimulating problems for the behavioral sciences. Furthermore, the solution to these problems at the interface between the physical and behavioral sciences is <u>important to physicists</u>, and in many cases to society as well.